PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Expansible and Self-folding Containers

We, AIR LOGISTICS CORPORATION, a corporation incorporated under the laws of the State of California, United States of America, of 3600 East Foothill Boulevard, Pasadena, California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to containers and, more particularly, to containers which are expansible by pressure from within the container, and are self-folding upon removal of the pressure.

Containers which can be expanded to over-all dimensions sufficient to accommodate a large volume of material to be shipped, and can then be folded when empty to substantially reduce over-all dimensions, are utilizable in a variety of situations. One-way material transport is often required which results in containers used to bring in a material being returned empty. Where a large bulk of material is involved, as in the case of transport of liquids, such as petroleum products, chemical products, or fresh water, the economic disadvantages attendant upon return of empty containers retaining their filled dimensions can in many instances make the transport of such materials unfeasible. For example, water transport of liquids in towed containers can be rendered uneconomical if it becomes necessary to return the empty containers in their original dimensions to the point of departure. This is particularly true where the return trip involves adverse oceanic or river currents. Comparable situations exist in transport of liquids by air, truck and trailer, or rail.

The present invention provides a container of high structural strength which is expansible to large over-all dimensions and is self-folding as emptied so that when folded it assumes substantially reduced dimensions. Although its use is not so limited, the structural strength and self-folding characteristics of a container of the present invention make it particularly adaptable for water transport of liquids in large quantities.

According to the present invention there is provided an expansible and self-folding container wherein walling of the container comprises a plurality of elongate sheets each having two longitudinal edges, a plurality of elongate flexible joint members of approximately U-shaped cross-section joining the elongate sheets along their longitudinal edges, each joint member having, in cross-section, a curved closure, a first leg portion extending from the curved closure and being joined to a longitudinal edge of one of the sheets, and a second leg portion extending from the curved closure and being joined to a longitudinal edge of another one of the sheets, the joint members being arranged to form alternately inwardly and outwardly projecting folds and being such that said self-folding of the container is positively produced thereby.

In one embodiment of the invention, the folded cross-section of the container consists of first and second pluralities of plastics sheets, each in a substantially corrugated pattern of sheets in the folded position. A wider first plastics sheet is joined at its longitudinal edges to an edge of the top sheet in each of the pluralities. A second plastics sheet, equal in width to the first sheet, is joined at its longitudinal edges to an edge of the bottom sheet in each of the pluralities. In this manner, the over-all dimensions of the folded container are reduced.

[*Price 4s. 6d.*]

Price 75p

The materials from which the joining means of the containers of a preferred embodiment of the present invention are made are characterised by a capability of storing energy without hysteresis loss. The structural requirement of a high ratio of tensile strength to tensile modulus of elasticity for the joining means is particularly found in filament-reinforced laminated thermosetting plastics materials. Reinforcement of such materials is achieved by a parallel array of natural or synthetic filaments in each of the laminae. In the laminated structure the filaments of a given lamina are oriented crosswise to the filaments in the overlying and/or underlying lamina. A preferred form of plastics material, sold under the trademark "Stratoglas", consists of fibre glass filaments bonded together with an epoxy resin to provide a reinforced laminated plastics material. The material possesses an unusual combination of structural strength and impact resistance. Its flexural characteristics and moldability permit forming of joints which produce longitudinal folds in the container as the contained liquid is withdrawn, and enable the container to assume an elliptical or circular cross-section as it is filled.

The container of the present invention and the manner of its use will be better understood from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a side view of one embodiment of the container of the present invention in a folded position;

Fig. 2 is an enlarged sectional view showing the container as seen along line 2—2 of Fig. 1 in a folded position;

Fig. 3 is a plan view of a plastics sheet removed from the container of Fig. 1;

Fig. 4 is an enlarged fragmentary view showing an embodiment of a joint used to join the plastics sheets of the container in Fig. 1;

Fig. 5 is an enlarged fragmentary sectional view generally taken along line 2—2 of Fig. 1 and showing a portion of the container in a partially expanded position;

Fig. 6 is a side elevational view of the container in its fully expanded position;

Fig. 7 is a fragmentary sectional view generally taken along line 7—7 of Fig. 6 and to a larger size after the container is in a fully expanded position;

Fig. 8 is an enlarged fragmentary view showing one of the joints and its associated sheets after the container is in a fully expanded position;

Fig. 9 is a fragmentary view showing another embodiment of a joint for joining the edges of the plastics sheets with the sheets in the folded position; and

Fig. 10 is a side elevational view of another embodiment of a container according to the present invention.

With reference to Figs. 1 and 2, a container 10, shown in its folded position, is formed from a plurality of flat sheets 12, of which one is shown in plan view in Fig. 3. The sheets are preferably formed of the same reinforced plastics material as the joints, which will be described. Since the sheets are not subject to an unusual amount of bending upon expansion, other more rigid materials may be employed for some containers. However, for unusually large containers, the inherent structural characteristics of the reinforced plastics materials enable use of a thin wall structure which provides a basic economy in material costs.

As shown in Fig. 3, each sheet includes a longitudinal edge 14 and a longer parallel longitudinal edge 16. The longitudinal edges are joined by angled edges 18 to provide a tapered end portion 20 at opposite ends of sheet 12. It will be understood that edges 18 may also be curved to provide tapered end portions.

As particularly shown in Figs. 1 and 2, each sheet 12 is joined along longitudinal edge 14 and angled edges 18 to the corresponding longitudinal edge and angled edges of an adjacent sheet by a joint piece 22, to be described. Similarly, longitudinal edge 16 is joined to the corresponding longitudinal edge of another adjacent sheet by a joint piece 22. The sheets are joined to provide a series of longitudinal folds. In cross-section, as shown in Fig. 2, the structure appears as two pluralities of sheets, each in a substantially corrugated pattern. An upper sheet 24, which is substantially wider than sheets 12, is joined at its longitudinal edges to a longitudinal edge of the uppermost sheet 12 in each of the pluralities. A lower sheet 26 is similarly joined to a longitudinal edge of the lowermost sheet 12 in each of the pluralities.

Joining of angled edges 18 of adjacent sheets at opposite ends of the sheets produces an envelope which defines an enclosure 28 within which fluids can be contained. The described structure can be made in a variety of sizes and may be utilized to provide containers of unusually large capacity. The container may be formed from reinforced plastics sheets, four to six feet in width and as long as required to meet the intended utilization.

The sheets are joined at their longitudinal edges by joint pieces 22, of which one embodiment is shown in enlarged detail in Fig. 4. This joint is molded from a reinforced laminated plastics material such as the product already described as sold under the trademark "Stratoglas". Sheets having an average thickness of about 1/16" (0.0625") can be used, and such sheets, consisting of oriented lamina or parallel glass filaments

bonded by an epoxy resin, provide a flexural yield strength as high as 180,000 p.s.i. in the direction of the filaments. The joint is formed by transversely folding a longitudinal strip upon itself to provide in cross-section a pair of parallel legs 30 extending from a curved closure 32. A scarf 34 is formed in the interior surface of each of the legs, and a corresponding scarf 36 is formed in each of the longitudinal edges and angled edges of the plastics sheet 12. A scarf joint is produced between each leg of joint piece 22 and the plastics sheet longitudinal edges 14 and angled edges 18 by bonding the corresponding scarfs together with a suitable resin or the like.

As to the material from which the joint pieces are formed, the ratio (S_M/E) of the tensile strength (S_M) to the modulus of elasticity (E) should be as high as possible. It can be shown that this ratio can be equated to the ratio (T/R) of the thickness of the material (T) to the radius of bend (R) of the joint. To meet many utilizations of the container of the present invention, the thickness must be great enough to provide the requisite strength while the radius of bend must be small enough to provide minimum over-all dimensions in the folded position of the container. Filament-reinforced laminated plastics materials of the type described meet these requirements. Their S_M/E ratio is between 0.03 and 0.04. With a material thickness of 0.1", a radius of bend between 2.5" to 3.3" can be obtained with retention of the self-folding characteristic.

After enclosure 28 within the container is, in its unexpanded position, filled with liquid the force exerted on the interior surfaces of plastics sheets 12 as additional liquid is forced under pressure into the chamber begins to expand the container. The sheets are moved outwardly between their longitudinal edges as the joints are opened. Fig. 5 shows the container in a partially expanded position. Continued addition of liquid expands the container to the fully expanded position shown in Fig. 7. The container has a substantially circular cross-section in this position. As particularly shown in Fig. 8, the flexural modulus of the joint material enables the joint pieces to be opened so that each leg of the joint is displaced from the other almost 90° from its position when the container is in a folded position. However, even with this degree of bending, the yield point of the material is not exceeded so that no permanent deformation of the joints and sheets defining the enclosure takes place. In its fully expanded condition the container is at least aproximately circular of elliptical in cross-section. Once the container has been transported to its destination and the enclosure is emptied, with attendant removal of pressure, the container returns to the initial folded position shown in Figs. 1 and 2.

Upon expansion of the container to its fully opened position, the angled edges of the adjacent sheets produce conical or tapered sections at opposite ends of the container. This is particularly shown in Fig. 6.

With reference to Fig. 9 an alternative embodiment of a joint piece for joining the longitudinal edges of the sheet is shown. The joint is formed by transversely folding a longitudinal strip upon itself to provide in cross-section a pair of parallel legs 38 extending from a curved closure 40. A scarf 42 is formed in the exterior surface of each leg. A portion of the surface of a plastics sheet 44 adjacent a longitudinal edge is bonded to the interior surface of one leg, and another plastics sheet 46 is similarly bonded to the other leg. A scarf 48 is formed in the interior surface of sheet 44, and a scarf 50 is formed in the interior surface of sheet 46. The scarfs are not utilized to form joints but provide a smooth transitional joinder in the inner and outer surface of the container. The joint shown in Fig. 9 is made of the same type of material as has been previously described. The joint responds to pressure and exhibits a self-folding characteristic, as has already been described with reference to the joint shown in Fig. 4.

The data provided in the table below show the force in pounds per linear inch required to expand a container having its joints made from 0.1" thick Stratoglas filament reinforced laminated plastics to different degrees of expansion where the radius of the bend of the joints is 3 inches:

% Expansion of Container Volume	Force Lbs./ Linear Inch Measured along Length of Container
50%	2.7
92%	6.9
96%	10.6
100%	44

Although it is generally preferred that sheets be shaped so that a means for completing an enclosure is integrally formed, flat sheets without end portions 20 of Fig. 3 may be joined together, as already described. In such an embodiment, resilient diaphragms 52 are joined to the ends of the sheets, as shown in Fig. 10. A neoprene-nylon material can be used to form the diaphragms, which, when the container is in the collapsed position such as illustrated in Fig. 1, are folded in a manner similar to a parachute. Expansion of the sheets to the circular cross-section previously described acts to stretch the diaphragms. In the fully expanded position, the cylindrical container shown in Fig. 10 is obtained.

WHAT WE CLAIM IS:—

1. An expansible and self-folding container wherein walling of the container comprises a plurality of elongate sheets each having two longitudinal edges, a plurality of elongate flexible joint members of approximately U-shaped cross-section joining the elongate sheets along their longitudinal edges, each joint member having, in cross-section, a curved closure, a first leg portion extending from the curved closure and being joined to a longitudinal edge of one of the sheets, and a second leg portion extending from the curved closure and being joined to a longitudinal edge of another one of the sheets, the joint members being arranged to form alternately inwardly and outwardly projecting folds and being such that said self-folding of the container is positively produced thereby.

2. A container as claimed in claim 1 wherein the sheets have angled edge portions at the ends of said longitudinal edges, the angled edge portions being joined together to provide an end closure of the container.

3. A container as claimed in claim 1 comprising means at the ends of the sheets and joint members to form an end closure of the container.

4. A container as claimed in claim 1, 2 or 3 wherein said joint members are of a reinforced plastics material including parallel fibreglass filaments bonded by a resin.

5. A container as claimed in any one of the preceding claims wherein each of said first and second legs defines a scarf on the inside surface thereof, the sheets having corresponding scarves along their longitudinal edges for mating with the scarves on the legs.

6. An expansible and self-folding container, substantially as hereinbefore described with reference to and as illustrated in Figs. 1 to 8, or as modified in Fig. 9 or Fig. 10, of the accompanying drawings.

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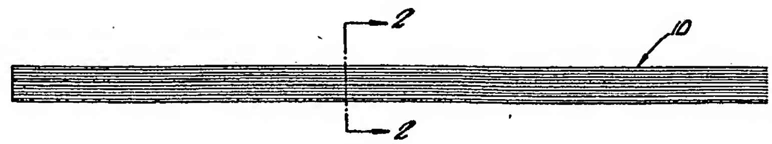
FIG. 1.



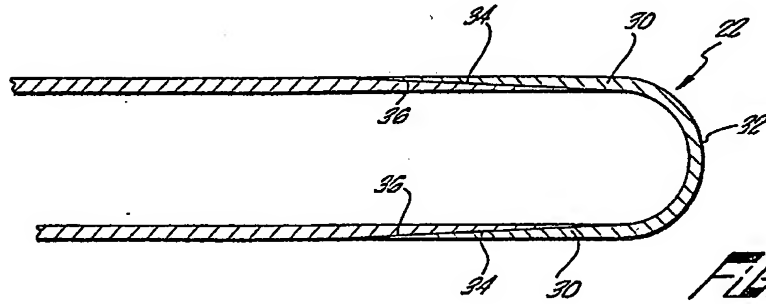


FIG. 4.

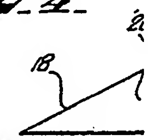


FIG. 6.

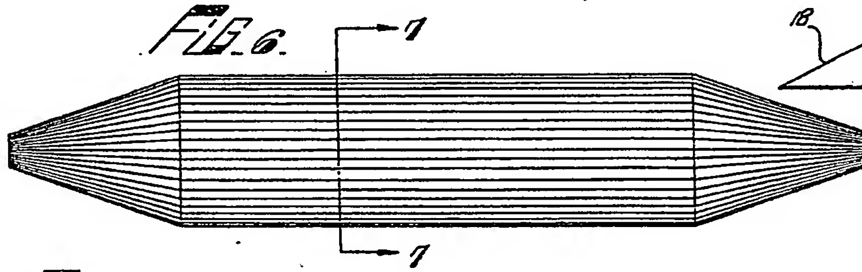


FIG. 9.

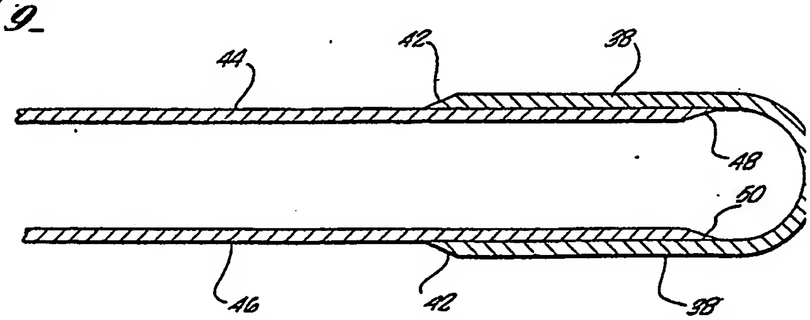
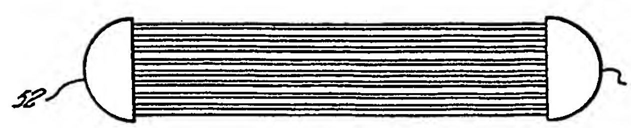


FIG. 10.



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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

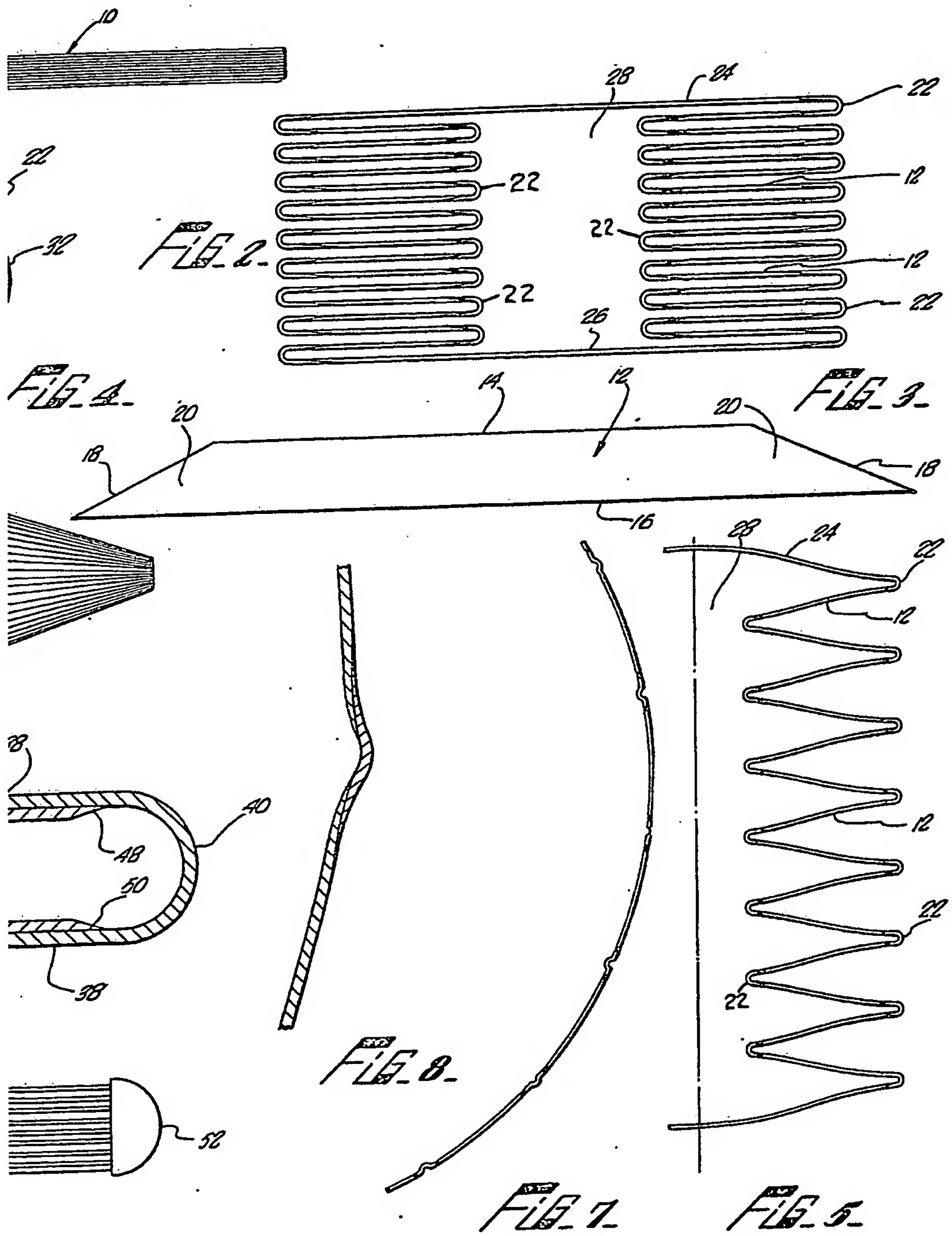

FIG. 2 FIG. 3 FIG. 4 FIG. 5 FIG. 7 FIG. 8

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

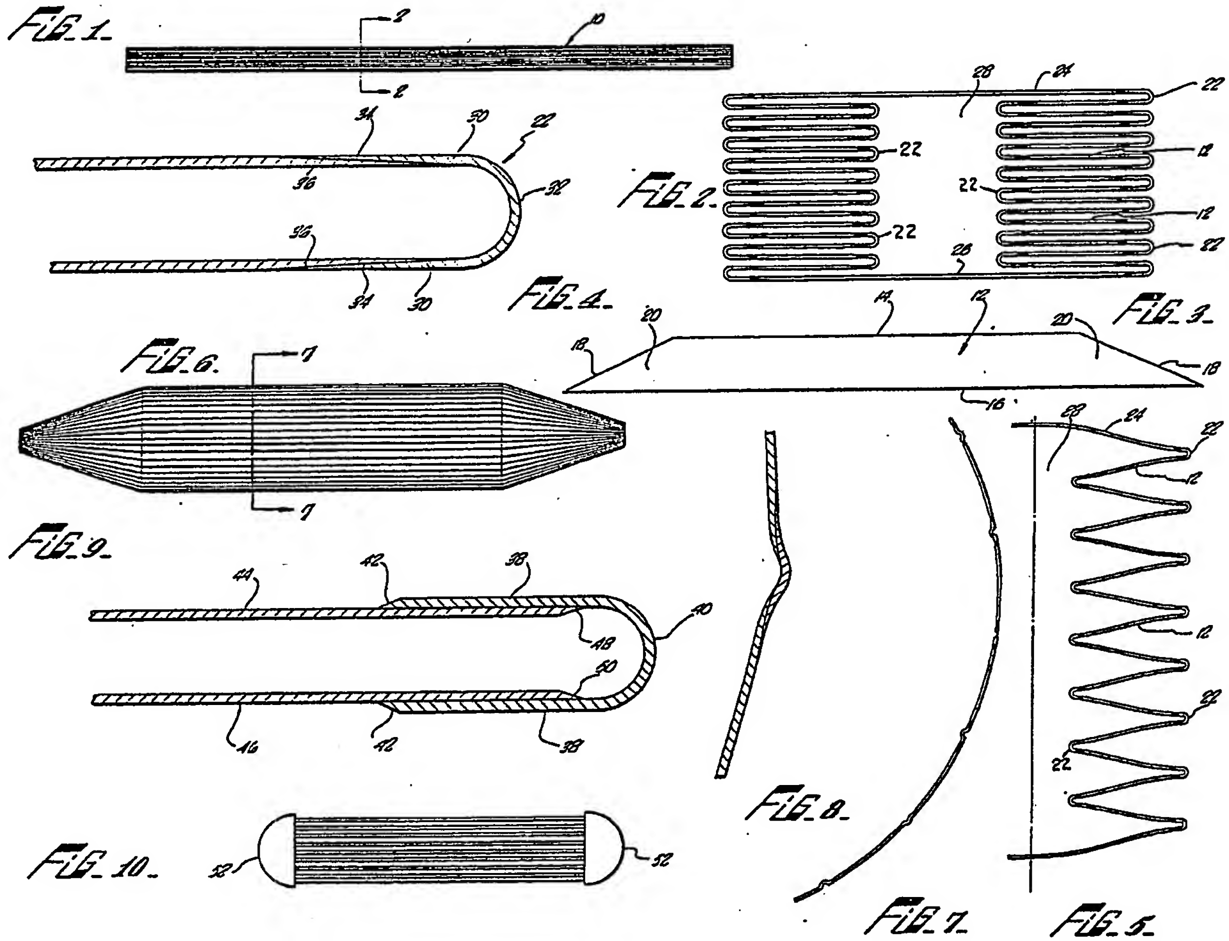

FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5. FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10.